JURNAL PSIKOLOGI
2002, NO. 1, 14 - 27

HAS ANGER 1000 FACES? HOW CONSISTENT ARE THE FACIAL EMG PATTERNS OF DIFFERENT METHODS TO ELICIT FACIAL ANGER EXPRESSION OF VARYING INTENSITIES?

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ABSTRACT

Do the usual methods to elicit angry faces yield the same EMG patterns and are the EMG activations of weakly angry faces weaker than those of intensely angry ones? 23 males were asked (1) to imagine 6 vignettes with family conflict situations (3 eliciting weak, 3 eliciting intense anger), (2) first to assess for 30 new conflict situations in the family, anger intensity and how each vignette fits their own family situation and then to imagine those 6 ones, that - for each participant - were extreme in anger intensity and convenient to imagine, (3) to remember and imagine 2 self-expierienced individual conflict situations with a parent (1 intensely angry, 1 weakly angry), (4) to make faces of slight vs. severe anger (same with disgust and joy), and finally (5) to imitate the facial expression of photos from respective series expressing high / low anger, disgust and joy. EMGs were recorded from corrugator supercilii, orbicularis oculi, levator labii and zygomaticus major. The data show that different methods to induce angry faces of high vs. low intensity yield EMG patterns not consistent across methods. Methods (1) and (3) did not yield a significant intensity effect in corrugator activity, but methods (2), (4) and (5) did. There is a considerable method heterogenity of anger expression in orbicularis oculi, levator labii and zygomaticus (even between methods (4) and (5)). This is in contrast to the facial EMG effects of joy and disgust which are in the expected direction in both methods (4 & 5), The anger results are in accordance with Ekman who found that in anger expression more different Action Units are involved than in any other basic emotion.

Keywords: *EMG, Emotion, Anger, Facial Expression*

Different types of emotional stimuli are employed in psychological studies which try to elucidate patterns of coactivation of facial muscle sites. The present study tries

ISSN : 0215 - 8884

to find out, if different commonly used stimuli, aimed to evoke the same emotion, activate the same muscle sites.

Facial muscle activity can be measured by using electromyographic (EMG) methods. These procedures are sensitive enough to detect covert facial expressions which are not readily apparent to the untrained eye. EMG research in the field of emotions has focused on certain facial muscles as the *corrugator supercilii* , the frowning muscle, the *zygomaticus major* , which - together with the *orbicularis oculi*, the ring muscle around the eyes - is activated during Duchenne smiling, and the *levator labii*, the muscle which wrinkles the nose.

Since these muscles are involved in the display of many emotions, they were included in the present study.

The present study was designed to investigated these four main questions:

1. What are the facial muscles that typically are sensitive to the expression of anger (*sensitivity effect*)?

   Can other muscles besides corrugator supercilii be identified as indicators of anger?

   Cacioppo, Bush & Tassinary, 1992, Cacioppo, Petty, Losch & Kim, 1986, Fridlund, Schwartz & Fowler, 1984, Zaleski, Crombez, Baeyens & Eelen, 1996) have shown that the frowning muscle, corrugator supercilii, is a general (that means unspecific) indicator of negative emotions.

2. a) Are differences in anger intensity induced via imagination of weakly vs.

   intensely angry situations and posing of weakly vs. intensely angry faces, respectively, reflected in corresponding EMG differences of the facial muscles identified as being involved in angry faces (*intensity effect*)?

   Similar studies have been conducted successfully by other researchers, e.g. Brown and Schwartz (1980), Cacioppo, Petty, Losch and Kim (1986) or Hess, Banse and Kappas (1995), suggesting that facial EMG allows not only for more general detection of facial expression of emotion, but also for finer differentiation of degrees of expressed feeling.

   b) Are there differences in the facial expressions elicited by different imagination procedures, all designed to induce weak vs. intense anger?

   One could also ask wether there are some imagination procedures more effective in eliciting differentiated facial expressions than others.

3. Are there differences in the facial EMG activity between imagery-induced and posed facial expressions of anger, regarding sensitivity and intensity effects?

   The results of Smith, McHugo & Lanzetta (1989), Hess, Kappas, McHugo, Kleck & Lanzetta (1989) or Rinn (1984), who described a seemingly double dissociation between posed and spontaneously occuring emotional facial expressions, suggest just this. As much research on emotional facial expression included posed expressions, this question is of great relevance.

4. Do posed expressions of anger and disgust, both negative emotions, differ in EMG activity, regarding sensitivity and intensity effects?

METHOD

Participants:

Participants are 22 male and 1 female student, aged 20 to 29 years with a mean of 23.1 years. Most of them were students of the University of the Federal Armed Forces Hamburg who fulfilled a study requirement.

Tasks in the experimental session:

a) Imagery Tasks:

(1) Imagination of 6 pretested vignettes, 3 known from an earlier study as inducing weak and 3 as inducing intense anger. These vignettes were the same for all subjects, but were classified as eliciting weak or strong anger according to the participants' anger ratings;

(2) Imagination of two situations from the participant's own experiences, one instigating weak and one intense anger;

(3) Imagination of another 6 vignettes (3 weakly, 3 intensely angry) chosen individually out of 30 vignettes according to their rated anger intensity and ease of vivid imagination.

Every imagination trial within these 3 tasks consisted of four phases:

A baseline phase (30 sec), during which the subjects were instructed to close their eyes, clear their heads and relax; a presentation phase (15 sec), when subjects read the particular vignette on the computer monitor; and the imagination phase (30 sec), during which the situation had to be imagined as lifely and vividly as possible. Each trial ended with a rating phase, when self-reports concerning anger, surprise, contempt, sadness and ease of imagination were assessed on visual analogue scales ranging from 0 to 100 (emotion ratings) and 5-point-Likert-scales (ease of imagination), respectively.

Due to other research purposes not discussed here all vignettes dealt with conflicts where father or mother elicited anger.Therefor, we assured that all subjects were in contact with at least one parent. Within each of the three tasks the vignettes were presented in random order.

b) Posing Tasks:

(1) Posing one's characteristic weakly and intensely angry, happy or disgusted face (each emotion and intensity was required twice in random order, resulting in 12 posing trials).

(2) Imitating photographs with weakly vs. intensely angry, happy and disgusted faces. Photographs were chosen due to independent ratings of five members of our research team from respective series by Ekman and Friesen (1976), Kirouac & DorÈ (1982) plus some own photos. Again, each emotion and intensity was required twice in random order, resulting in 12 posing trials.

Each posing trial began with a 20 sec baseline, during which the participants had to close their eyes and relax, followed by a 20 sec posing phase, during which the instruction to pose one of the typical faces or the photograph, respectively, was

presented all the time. Each trial ended with a rating how well the participant felt to have fulfilled the instruction.

The experiment was realized on a portable personal computer. Instructions, vignettes and photographs were presented visually on the display and ratings were given via mouse clicks.

Dependent variables / electrode sites:

During the whole experimental session EMG was assessed at the following electrode sites:

1. corrugator supercilii
2. zygomaticus major
3. orbicularis oculi
4. levator labii

After conventional skin preparation bipolar sensormedics' Ag/AgCl-electrodes, 2.7 mm in diameter, were filled with signa electrode cream and placed over the four electrode sites with a between electrodes distance as small as possible. All pairs were referenced to a forehead ground electrode.

Electrode sites were chosen because they are suspected to be involved in the facial expression of anger, but also happiness and disgust (see Ekman & Friesen, 1978; Carroll & Russell, 1997).

Point of best imagery resp. posing was indicated by the participants by raising their nondominant hand against the resistance of an elastic band and measured by the EMG activity of the *m. carpi ulnaris* at the forearm. As measure of the imagery and posing phases only the 10 seconds around the hand raising were taken.

Data were collected by a portable multichannel polygraph PARPORT-F (PAR electronic, Berlin, Germany) using high pass filters (>= 90 Hz) to avoid artifacts (gross movements, ECG, cross-talks), and a conventional integration interval across 1 second.

Data reduction followed by averaging values across the whole baseline phase (except first and last second) and 10 seconds of the point of best imagination and posing as described above.

Last but not least subjects were debriefed and asked not to tell their peers about the course and purposes of the experiment.

Data analysis:

Sensitivity effects

To reveal *sensitivity effects* we compared pooled baselines (averaged across all trials within each task) with pooled imagination or posing phases (also averaged across all trials within each task without regard of intensity) via paired t-tests.

Intensity effects

To reveal *intensity effects* we compared the pooled imagination resp. posing phases of the two different degrees of emotion intensity (averaged across all trials within each task reflecting the same intensity) with each other via paired t-tests.

Additional analyses of variance will be explained in the respective paragraphs.

RESULTS

1. Imagery Tasks

Results of the imagery tasks are depicted in *table 1* and *figure 1*.

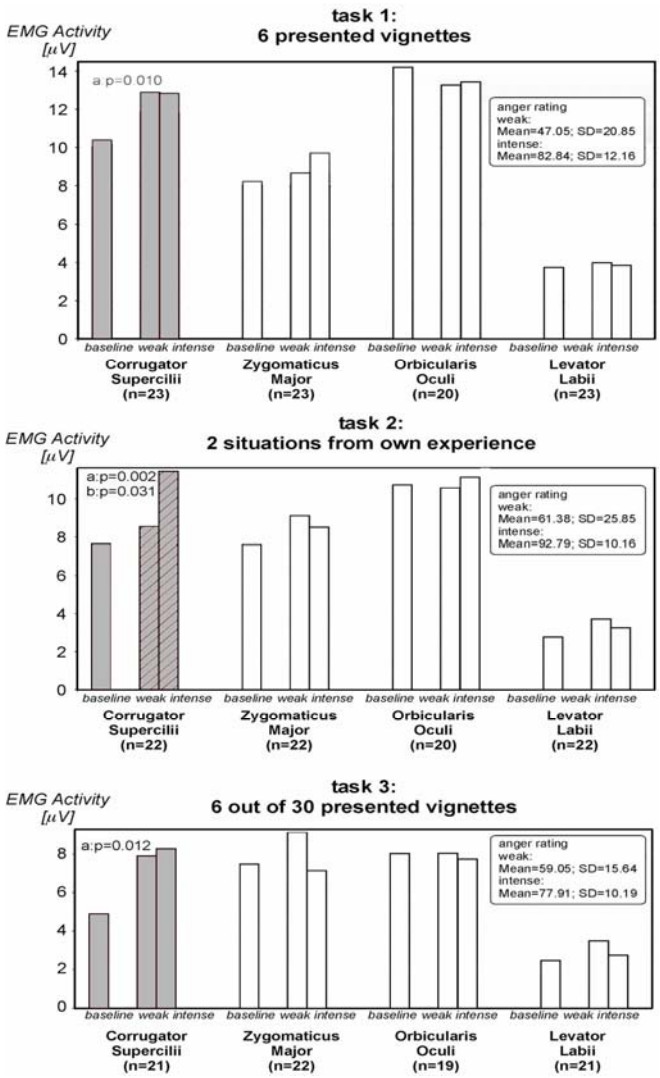

Figure 1. Mean amplitude of integrated electromyographic activity over the *corrugator supercilii, zygomaticus major, orbicularis oculi* and *levator labii* electrode sites during baselines and imagination of weakly vs. intensely angry situations in tasks (1), (2) and (3). Significant sensitivity effects are indicated by grayness of the respective bars. Significance level is noted behind the letter **a**. Significant intensity effects are indicated by hatching of the respective bars. Significance level is noted behind the letter **b**. Changing numbers of subjects are resulting from data exclusion because of detached electrodes.**Insert Fig 1 here!**

ISSN : 0215 - 8884

In all three tasks significant differences between pooled baselines and imagery phases (sensitivity effects) could only be observed at the corrugator supercilii electrode site. Furthermore, a significant difference between imagination of weakly vs. intensely angry situations (intensity effect) could only be found in task (2), the imagination of situations from own experience.

Table 1. Means and standard deviations (in parentheses) of integrated EMG activity during baselines and imagery phases, averaged across three trials concerning tasks (2) and (3) (six trials for baselines, respectively). Baseline data for task (2) are averaged across two trials.

		task 1	task 2	task 3
CS	baseline	10.39 **a** (11.41)	7.64 **a** (8.54)	4.90 **a** (5.26)
	weak	12.90 (11.85)	8.56 (8.02)	7.89 (6.23)
	intense	12.83 (11.46)	11.44 **b** (8.45)	8.27 (7.89)
ZY	baseline	8.27 (14.97)	7.62 (12.32)	7.47 (12.25)
	weak	8.66 (15.54)	9.12 (12.52)	9.13 (15.77)
	intense	9.71 (19.31)	8.50 (14.37)	7.14 (13.31)
OO	baseline	14.19 (14.42)	10.72 (9.53)	8.02 (6.52)
	weak	13.27 (13.73)	10.58 (10.58)	8.03 (6.52)
	intense	13.44 (14.16)	11.13 (10.26)	7.73 (6.91)
LL	baseline	3.74 (5.13)	2.77 (3.20)	2.48 (2.16)
	weak	3.99 (4.77)	3.71 (3.90)	3.49 (3.29)
	intense	3.85 (4.14)	3.24 (3.27)	2.75 (1.83)

Note. CS = corrugator supercilii, ZY = zygomaticus major, OO = orbicularis oculi and LL = levator labii. Significant differences betweeen pooled baselines and posing phases (sensitivity effects) are indicated by the letter **a**. Significant differences between weakly and intensely emotional facial expressions (intensity effects) are indicated the letter **b**. $p < 0.05$.

To rule out that this effect exclusively found in task (2) is due to higher differences in anger intensity between weakly and intensely angry self-generated situations compared to the respective differences in tasks (1) and (3), the individual differences in *rated* anger intensity were compared between the three tasks. They didn't differ significantly between task (1) and (2) (31.4 vs. 35.8), thus cannot explain the EMG-differences between task (1) and (2).

Obviously, the overall level of anger which was highest for situations from own experience (77.1 (task 2) vs. 65 (task 1) and 68.5 (task 3)) seems to be more important.

In all three tasks the differences between the anger ratings for weakly and intensely angry situations were significant as expected ($p < 0.05$). For most of the situations (except weakly angry situations in task 1), anger was the dominant emotion in respect of the sample means. In some tasks weakly and intensely angry situations also differed in other emotion ratings as can be seen in *table 2*.

Table 2. Means and standard deviations (in parentheses) of ratings collected during tasks (1) to (3) (pooled across situations in tasks (1) and (3)).

		anger	sadness	contempt	surprise	ease of imagination
task 1	weak	47.05** (20.85)	33.48** (22.53)	17.68** (14.92)	47.11 (19.83)	3.48** (0.69)
	intense	82.84 (12.16)	50.36 (15.85)	36.20 (28.31)	53.02 (21.67)	3.88 (0.45)
task 2	weak	61.38** (25.85)	32.26 (31.10)	22.21** (26.16)	41.51 (32.33)	4.64 (0.58)
	intense	92.79 (10.16)	50.27 (35.10)	44.56 (26.56)	38.91 (31.18)	4.73 (0.46)
task 3	weak	59.05** (15.64)	38.04* (25.44)	29.78 (26.75)	45.74 (21.23)	3.87 (0.72)
	intense	77.91 (10.19)	47.63 (21.94)	34.27 (24.27)	45.05 (20.34)	3.80 (0.70)

Note. Significant differences between weakly and intensely angry situations are indicated by asterisks (* $p < 0.05$, ** $p > 0.01$). Emotion ratings were assessed on visual analogue scales ranging from 0 to 100. Ease of imagination was assessed on a 5-point-Likert-scale ranging from 1 (not at all imaginable) to 5 (very exactly imaginable).

2. Posing Tasks

Results of the posing tasks, making one's own characteristic emotional face (task 4) and imitating photographs of emotional expressions (task 5), are depicted in *table 3* and *figure2*a), b) and c).

For *happiness* the patterns of EMG activity were the same in both tasks: all muscles except corrugator supercilii showed significant sensitivity as well as intensity effects.

Looking at *disgust,* effects in both tasks were similar, but not quite as homogeneous. There were significant sensitivity as well as intensity effects in all electrode sites in task (4), except in the zygomaticus major where the sensitivity effect did not reach significance.

In task (5), there were significant sensitivity and intensity effects in all electrode sites except orbicularis oculi where there was at least a significant sensitivity effect.

When we look at *anger*, the results differed considerably between the two tasks: there were significant sensitivity as well as intensity effects in the corrugator supercilii in both tasks. Significant sensitivity effects could be found in the zygomaticus major and levator labii in task (4) and only in the levator labii in task (5), whereas significant intensity effects occured in all the remaining three electrode sites in task (4) (EMG acitivity was always higher in posing intense anger), but only in the zygomaticus major in task (5) (EMG activity was higher in posing weak anger).

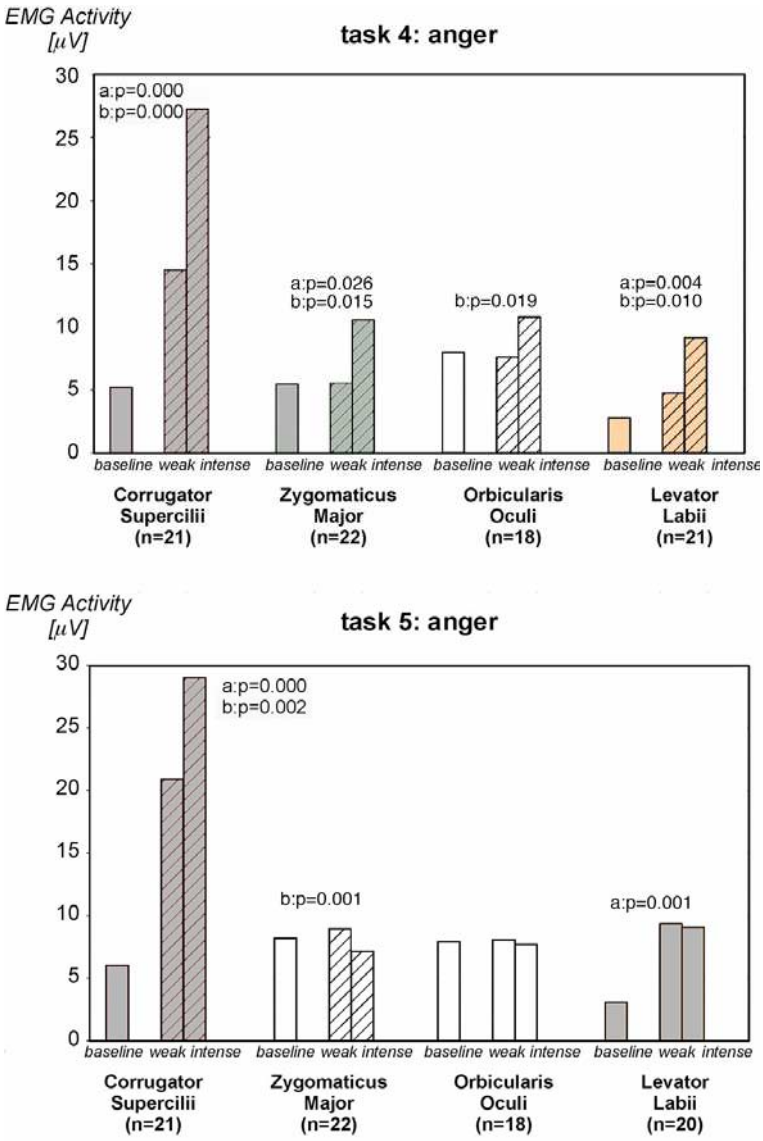

Figure 2 a) Mean amplitude of integrated electromyographic activity over the *corrugator supercilii, zygomaticus major, orbicularis oculi* and *levator labii* electrode sites during baselines, weakly and intensely angry posed facial expressions in tasks (4) and (5). Significant sensitivity effects are indicated by grayness of the respective bars. Significance level is noted behind the letter **a**. Significant intensity effects are indicated by hatching of the respective bars. Significance level is noted behind the letter **b**. Changing numbers of subjects are resulting from data exclusion because of detached electrodes.

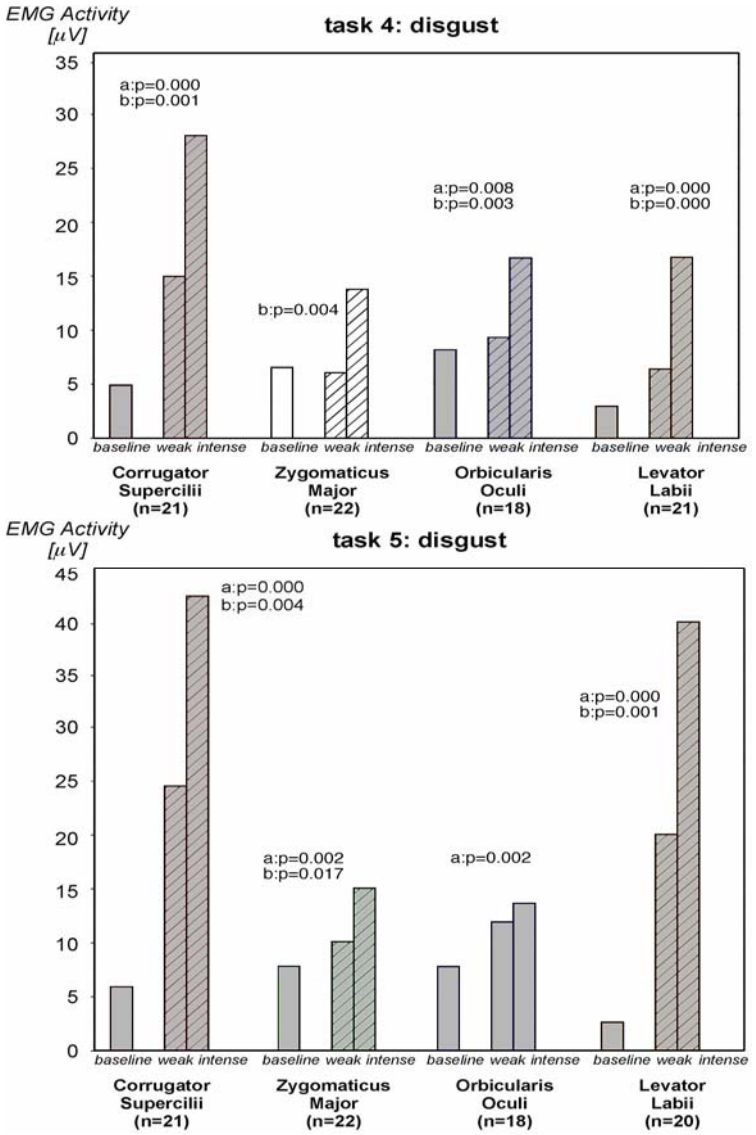

Figure 2 b). Mean amplitude of integrated electromyographic activity over the *corrugator supercilii, zygomaticus major, orbicularis oculi* and *levator labii* electrode sites during baselines, weakly and intensely disgusted posed facial expressions in tasks (4) and (5). Significant sensitivity effects are indicated by grayness of the respective bars. Significance level is noted behind the letter **a**. Significant intensity effects are indicated by hatching of the respective bars. Significance level is noted behind the letter **b**. Changing numbers of subjects are resulting from data exclusion because of detached electrodes.

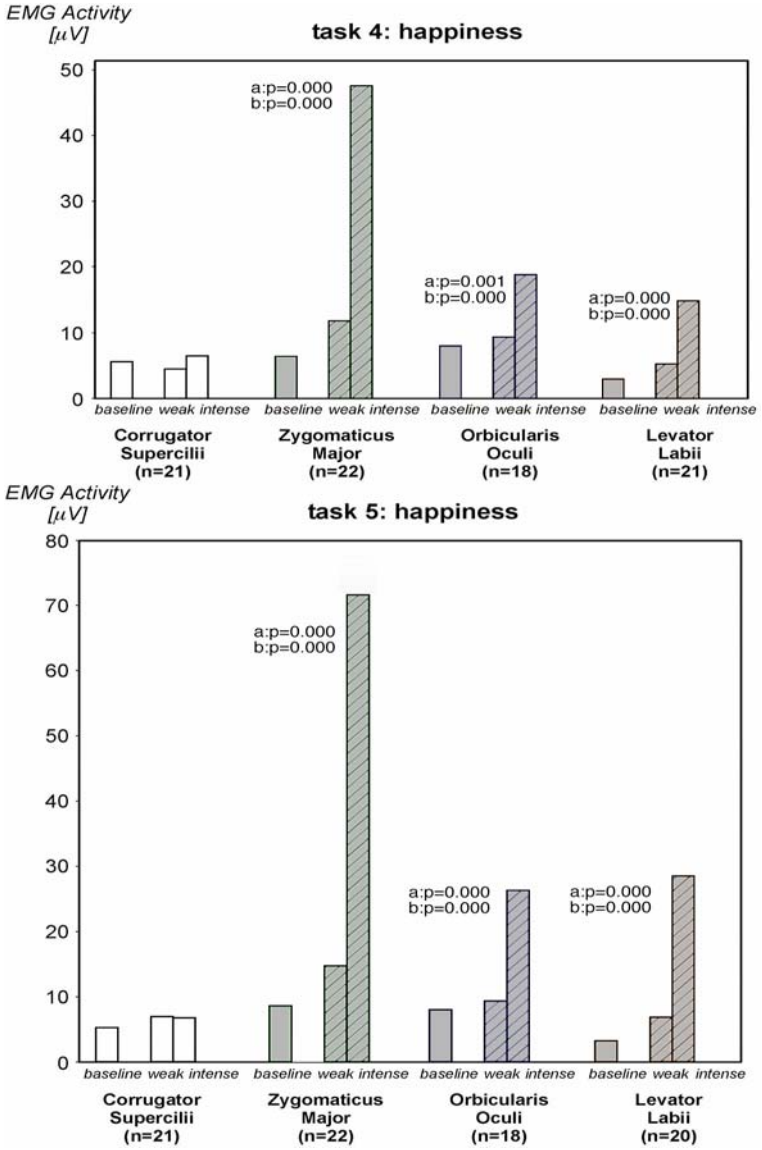

Figure 2 c). Mean amplitude of integrated electromyographic activity over the *corrugator supercilii, zygomaticus major, orbicularis oculi* and *levator labii* electrode sites during baselines, weakly and intensely happy posed facial expressions in tasks (4) and (5). Significant sensitivity effects are indicated by grayness of the respective bars. Significance level is noted behind the letter **a**. Significant intensity effects are indicated by hatching of the respective bars. Significance level is noted behind the letter **b**. Changing numbers of subjects are resulting from data exclusion because of detached electrodes.

Table 3. Means and standard deviations (in parentheses) of integrated EMG activity during baselines, weakly and intensely angry, disgusted and happy posed facial expressions in tasks (4) and (5), averaged across two trials each time.

		happiness		anger		disgust	
		task 4	task 5	task 4	task 5	task 4	task 5
CS	baseline	5.62 (5.22)	5.30 (5.67)	5.20 **a** (4.48)	6.02 **a** (5.25)	4.89 **a** (4.76)	5.93 **a** (5.63)
	weak	4.50 (5.51)	6.98 (9.44)	14.49 (8.61)	20.89 (11.02)	14.99 (9.44)	24.65 (18.20)
	intense	6.47 (9.76)	6.77 (11.31)	27.25 **b** (14.23)	29.02 **b** (16.71)	28.04 **b** (18.99)	42.83 **b** (32.10)
ZY	baseline	6.45 **a** (9.22)	8.61 **a** (15.99)	5.44 **a** (8.06)	8.19 (16.56)	6.52 (9.74)	7.85 **a** (16.28)
	weak	11.83 (9.01)	14.75 (15.98)	5.58 (8.75)	8.93 (17.11)	6.07 (8.18)	10.12 (16.13)
	intense	47.59 **b** (33.53)	71.59 **b** (40.60)	10.55 **b** (11.74)	7.15 **b** (15.89)	13.81 **b** (15.10)	15.14 **b** (19.94)
OO	baseline	8.01 **a** (5.96)	8.03 **a** (5.38)	7.97 (6.63)	7.91 (5.35)	8.18 **a** (6.66)	7.83 **a** (5.58)
	weak	9.40 (6.46)	9.38 (6.59)	7.61 (6.82)	8.05 (4.90)	9.35 (6.66)	11.98 (8.76)
	intense	18.81 **b** (10.33)	26.33 **b** (13.11)	10.78 **b** (8.18)	7.71 (6.05)	16.70 **b** (13.16)	13.75 (7.85)
LL	baseline	2.95 **a** (2.35)	3.23 **a** (3.56)	2.80 **a** (2.40)	3.07 **a** (2.27)	2.93 **a** (2.51)	2.64 **a** (2.12)
	weak	5.28 (3.38)	6.87 (6.66)	4.68 (4.60)	9.35 (10.32)	6.38 (4.24)	20.14 (14.72)
	intense	14.88 **b** (9.66)	28.48 **b** (24.05)	9.15 **b** (9.61)	9.07 (10.39)	16.78 **b** (11.80)	39.93 **b** (24.19)

Note. CS = corrugator supercilii, ZY = zygomaticus major, OO = orbicularis oculi and LL = levator labii. Significant differences betweeen pooled baselines and posing phases are indicated by the letter **a**. Significant differences between weakly and intensely emotional facial expressions are indicated the letter **b**. $p < 0.05$.

When asked how well the participants believed to have fulfilled the posing tasks, a 2 (tasks) x 3 (emotions) x 2 (intensities) repeated measures analysis of variance revealed that subjects perceived their posing quality as better in task (4) than in task (5) (main effect of task: $F(1, 22) = 14.02$, $p = .001$); happiness got the best ratings, anger the worst and disgust was in between (main effect of emotion: $F(2, 44) = 10.76$, $p = .000$). There was also a significant interaction between emotion and task ($F(2,44) = 9.72$, $p = .000$) in that the difference between tasks (4) and (5) was largest for anger.

3. Comparing Imagery and Posing Tasks Concerning Anger

To compare the results of the imagery and posing tasks for anger, the EMG activity over each electrode site was averaged across tasks (1), (2) and (3) for imagery and across tasks (4) and (5) for posing, separately for weak and intense anger. For each electrode site a 2 (task) x 2 (intensity) repeated measures analysis of variance was conducted. For corrugator supercilii, activity was higher for posing than for imagery ($F(1,20) = 33.24$, $p = .000$), higher for intense anger than for weak anger ($F(1,20) = 34.88$, $p = .000$) and the difference between intensities was larger for posing than for imagery ($F(1,20) = 25.26$, $p = .000$).

For zygomaticus major, the differences between intensities was much larger in the posing tasks than in the imagery tasks (significant interaction, $F(1,21) = 4.83$, $p = .039$). For orbicularis oculi, activity in posing as well as imagery was higher for intense anger (main effect of intensity, $F(1,17) = 4.90$, $p = .041$). For levator labii, activity was much higher in the posing tasks than in the imagery tasks (main effect of task, $F(1,20) = 12.45$, $p = .002$).

4. Comparing Posed Anger and Disgust

Eight 2 (emotion) x 2 (intensity) repeated measures analyses of variance were conducted, separately for tasks and electrode sites.

In task (4), all electrode sites showed significant effects of intensity (corrugator: $F(1,20) = 34.75$, $p = .000$; zygomaticus: $F(1,21) = 13.48$, $p = .001$; orbicularis: $F(1,17) = 13.02$, $p = .002$; levator: $F(1,20) = 18.06$, $p = .000$), but only orbicularis oculi and levator labii also showed significant effects of emotion (orbicularis: $F(1,17) = 9.71$, $p = .006$; levator: $F(1,20) = 13.31$, $p = .002$) and significant interaction effects in that activity was higher in disgust than in anger, especially while posing intense emotion (orbicularis: $F(1,17) = 4.81$, $p = .042$; levator: $F(1,20) = 7.95$, $p = .011$).

In task (5), significant main effects of emotion were found for all electrode sites: activity was always higher in disgust than in anger (corrugator: $F(1,20) = 5.96$, $p = .024$; zygomaticus: $F(1,21) = 12.97$, $p = .002$; orbicularis: $F(1,17) = 20.27$, $p = .000$; levator: $F(1,19) = 41.09$, $p = .000$). Effects of intensity could only be found in corrugator supercilii ($F(1,20) = 15.71$, $p = .001$) and levator labii ($F(19,1) = 10.81$, $p = .004$), and significant interaction effects were found for zygomaticus major ($F(1,21) = 11.26$, $p = .003$) and levator labii ($F(1,19) = 13.17$, $p = .002$): differences between anger and disgust were more pronounced during posing of intense emotion.

DISCUSSION

Only corrugator supercilii EMG proved to be sensitive for facial expressions of anger in all the tasks. But activity over this muscle region is not anger-specific, since it also occured in posing disgust, thus reflecting the well-known feature of corrugator EMG to distinguish between facial expressions of positive vs. negative emotions.

While in imagery-induced facial expressions of anger no other muscle region than corrugator showed any activity, in both posing tasks levator labii was

activated additionally. Specific for task (4) was just the additional increase in zygomaticus activity. Higher activity over the zygomaticus – the muscle of smiling – while posing angry faces compared to baseline activity or to neutral faces has been found by other researchers before (e.g. Smith, McHugo & Lanzetta, 1986).

Corrugator, the only muscle reliably sensitive to anger in all 3 imagery tasks, reflected differences in anger intensity only in task (2), where own experiences had to be visualized, not in standard situations, designed by the experimenter.

This result was unexpected, as Brown & Schwartz (1980) found intensity effects at the corrugator site with standard situations. A possible explanation is that their standard situations had a higher self-relevance than ours. That personal relevance is important to elicit physiological reactions was demonstrated by Velasco & Bond (1998) for SCL and SCF. Another explanation why only task (2) yielded significant intensity differences in the corrugator activity may be, that a certain threshold of anger intensity must be reached to be detected in the EMG (but Brown & Schwartz (1980) found corrugator-differences already between mild and moderate anger eliciting situations).

When posing one's own characteristic angry face in task (4), all muscles sensitive to anger discriminated between anger intensities as well (corrugator, levator labii and zygomaticus showed increased activity). Furthermore, the activity of the orbicularis oculi increased. In the imitation task (5) increases in intensity of anger were reflected by an *increase* of corrugator activity only and by a *decrease* in zygomaticus activity. Increases as well as decreases in zygomaticus activity during negative emotions are reported in the literature as well but have not yet been investigated systematically.

When posing one's characteristic angry face, all muscles are activated to differentiate between weakly and intensely angry faces. This corresponds with our observation, that when you look at a TV scene only for a second, you can always distinguish immediately if it is real life or fictious, (t.i. posed expression): posed faces are more expressive (use more muscles and activate them stronger). (See also Carroll & Russell's (1997) study with Hollywood actors.)

Posed and imagery-induced facial expressions of anger have nothing in common but the corrugator activity. The degree of activity is much higher for posed faces.

Besides this commonality there is a considerable variation between the faces; thus there are 1000 faces of anger.

Angry (posed) faces can be differentiated from posed disgust faces not by the muscles involved but by the extend of their activation: disgust yields higher activation than anger.

Why are the muscles activated in the two different posing tasks of anger more hetero-geneous than that involved in happiness and disgust? We believe that the expression of anger is much more regulated by complex and highly context specific display rules (Ekman, 1972) than that of disgust (and happiness as well) (see Cantin & Hess, 1997, on the importance of situational factors in anger reactions).

ISSN : 0215 - 8884

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